AL/HR-TR-1993-0111

NIGHT VISION GOGGLE MODEL F4949 PREFLIGHT ADJUSTMENT/ASSESSMENT PROCEDURES

Joseph C. Antonio

University of Dayton Research Institute
300 College Park Avenue
Dayton, OH 45469-0110

William E. Berkley, Colonel, USAF

HUMAN RESOURCES DIRECTORATE
AIRCREW TRAINING RESEARCH DIVISION
6001 South Power Road, Building 558
Mesa, AZ 85206-0904

August 1993

Final Technical Report for Period March 1993 - June 1993

Approved for public release; distribution is unlimited.

AIR FORCE MATERIEL COMMAND
BROOKS AIR FORCE BASE, TEXAS

ARMSTRONG LABORATORY

NOTICES

This technical report is published as received and has not been edited by the technical editing staff of the Armstrong Laboratory.

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely Government-related procurement, the United States Government incurs no responsibility or any obligation whatsoever. The fact that the Government may have formulated or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication, or otherwise in any manner construed, as licensing the holder, or any other person or corporation; or as conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public.

This report has been reviewed and is approved for publication.

Elizabeth L. Martin

ELIZABETH L. MARTIN
Project Scientist

Dee H. Andrews

DEE H. ANDREWS
Technical Director

Lynn A. Carroll

LYNN A. CARROLL, Colonel, USAF
Chief, Aircrew Training Research Division

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	August 1993	Final March 1993 - June 1993

4. TITLE AND SUBTITLE

Night Vision Goggle Model F4949 Preflight Adjustment/Assessment Procedures

5. FUNDING NUMBERS

C - F33615-90-C-0005
PE - 62205F
PR - 1123
TA - 03, 32
WU - 85, 06

6. AUTHOR(S)
Joseph C. Antonio
William E. Berkley

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

University of Dayton Research Institute
300 College Park Avenue
Dayton, OH 45469-0110

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Armstrong Laboratory (AFMC)
Human Resources Directorate
Aircrew Training Research Division
6001 South Power Road, Building 558
Mesa, AZ 85206-0904

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

AL/HR-TR-1993-0111

11. SUPPLEMENTARY NOTES

Armstrong Laboratory Technical Monitor: Dr. Elizabeth L. Martin, (602) 988-6561

12a. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Night vision goggles (NVGs) have been employed in a variety of aircraft for over twenty years. However, only recently has their application begun in fixed-wing fast movers. Research accomplished by the Night Vision Programs Office at the Aircrew Training Research Division of the USAF Armstrong Laboratory demonstrated the loss of NVG performance resulting from improper adjustments. This report describes correct adjustment procedures for the F4949 NVG system. The procedures described were developed so aircrews could take advantage of the adjustments available on the NVGs. Additionally, image descriptions are given to help aircrews evaluate NVG performance. Information on the proper equipment/space needed for proper evaluation is also included.

14. SUBJECT TERMS				15. NUMBER OF PAGES
Adjustment procedures	Eye lane	IPD	NVG	26
Alignment procedures	F4949	Night vision devices		16. PRICE CODE
Diopter	Focusing procedures	Night vision goggles		
	Interpupillary distance	NVD		

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	UL

CONTENTS

FIGURES

TABLE

PREFACE

This work was conducted at the Armstrong Laboratory, Aircrew Training Research Division (AL/HRA) in Mesa, Arizona by the University of Dayton Research Institute (UDRI). Among many other research efforts, AL/HRA conducts visual training effectiveness research in support of aircrew training technology. One entity of this effort is the night vision training research program.

UDRI, working under Contract F33615-90-C-0005, is developing prototype instructional media and courseware to be used in aircrew night vision goggle (NVG) training. This report contains instructions for Air Force pilots to use in properly adjusting F4949 NVGs to maximize optical performance. The laboratory contract monitor was Ms Patricia A. Spears and the effort was managed under Work Unit 1123-03-85, Flying Training Research Support. The laboratory task order monitor was Dr Elizabeth L. Martin.

The author would like to thank Ms M.E. McConnon and Ms D.L. Bolin, UDRI, for their creative abilities in assembling this report.

NIGHT VISION GOGGLE MODEL F4949

PREFLIGHT ADJUSTMENT/ASSESSMENT PROCEDURES

INTRODUCTION

Night vision goggles (NVGs) have become an integral part of night operations in many aircraft. Properly fit and adjusted, they dramatically enhance night vision. However, improper adjustment can severely degrade visual acuity. While NVGs are not difficult to use, one must understand their design characteristics in order to obtain maximum performance from them. This report presents the basic preflight adjustment and assessment procedures for the F4949 system.

NVG COMPONENTS

F4949 NVGs consist of two components, (a) the mount assembly and (b) the binocular assembly (Fig. 1).

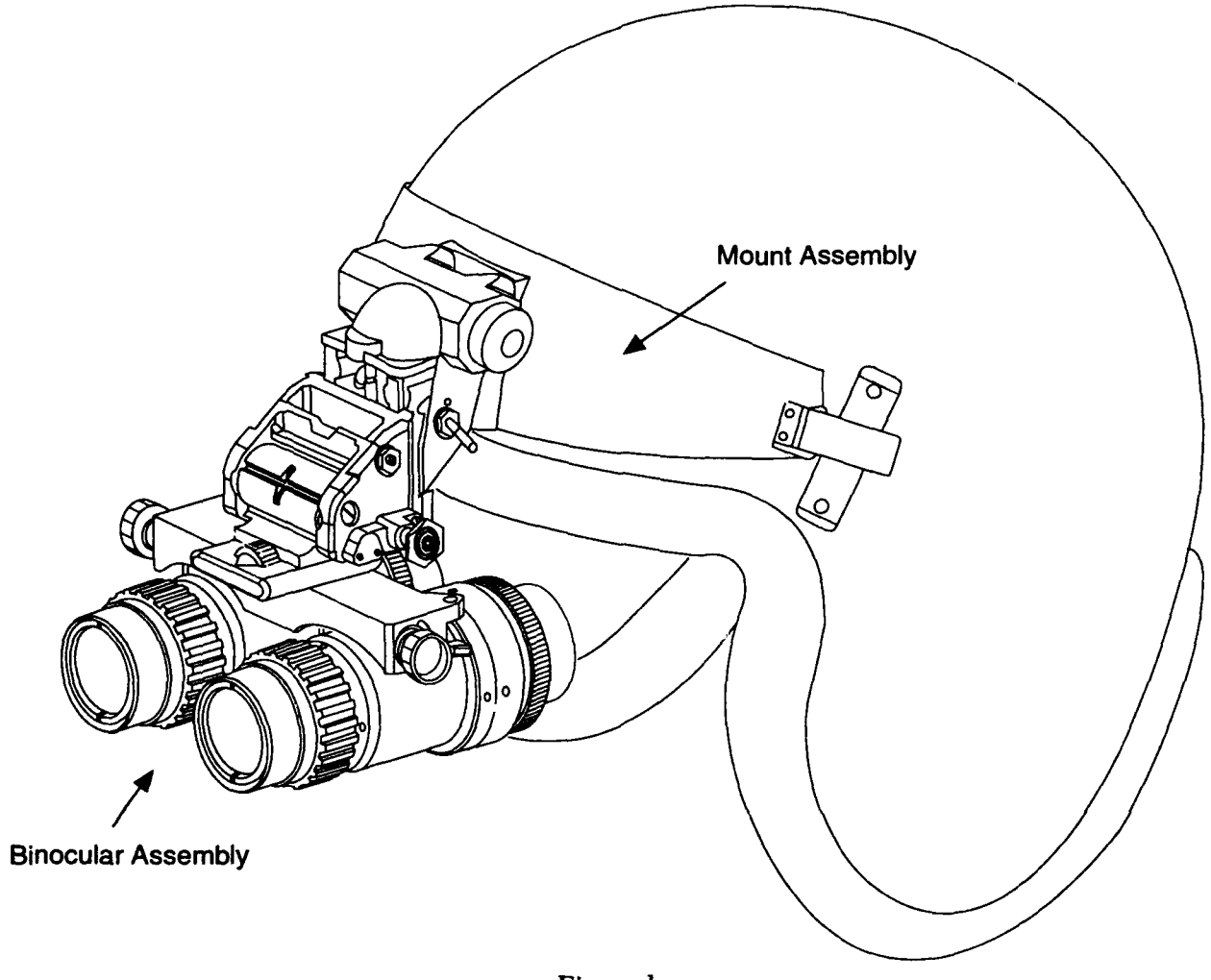


Figure 1
F4949 NVG Components

The Mount Assembly

The mount assembly (Fig. 2) is secured to the helmet and holds the binocular assembly in position. Different mount assemblies are provided for the HGU-53P and HGU-55P helmets. Although they appear identical, they are not interchangeable because of slight differences in their dimensions. Each assembly has the following adjustments/subcomponents:

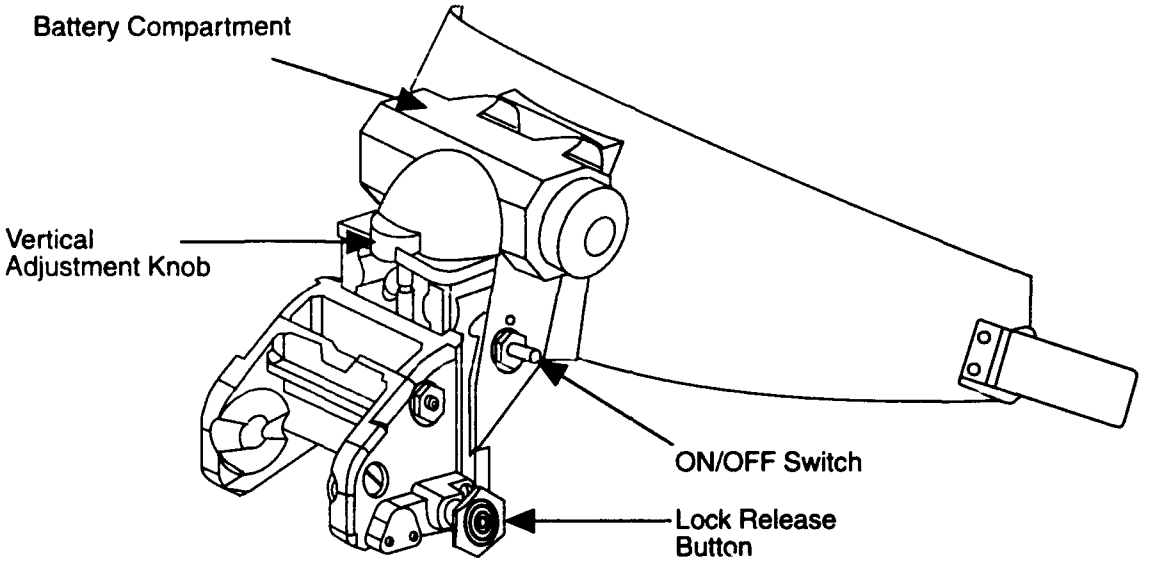


Figure 2
F4949 Mount Assembly

Vertical Adjustment Knob. Moves the binocular assembly up and down.

Lock Release Button. Releases the binocular assembly to permit rotation from the stowed position to the operating position, and vice versa. The lock release button should always be employed when rotating the binocular assembly. Otherwise, excessive wear of the latching mechanism will occur and the goggle will not latch securely in the stowed position, and may bounce up and down in the operating position during abrupt head movements or turbulence.

Battery Compartment. Incorporates two separate compartments, each for a single half-AA lithium battery. The goggle is operated by a single battery, determined by the position of the on/off switch.

ON/OFF Switch. A three-position switch is located on the left side of the battery compartment. The up position selects the right battery (from the wearer's perspective) and the down position selects the left battery. The center position is off.

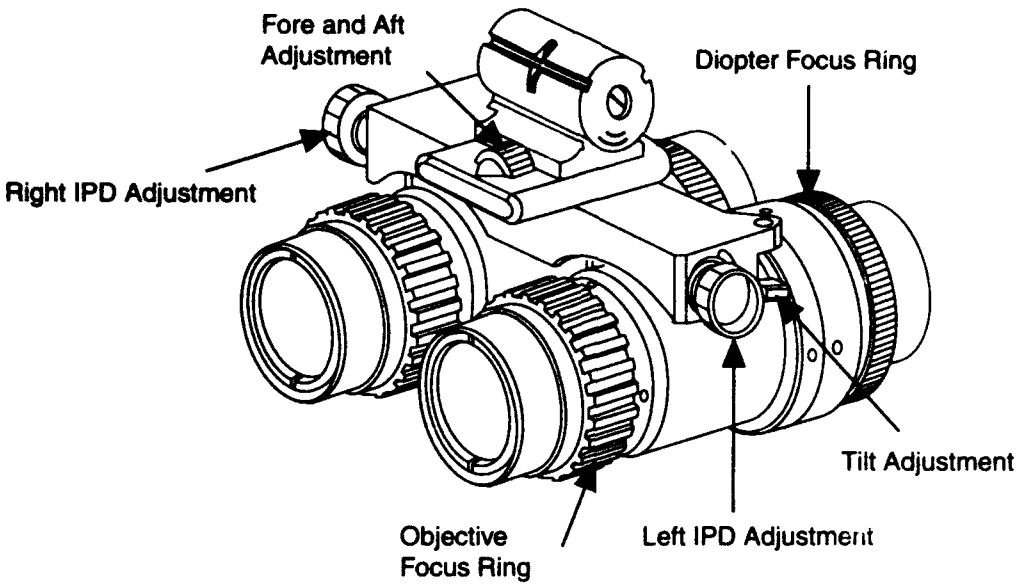


Figure 3
F4949 Binocular Assembly

The Binocular Assembly

The binocular assembly (Fig. 3) consists of a pair of monocular assemblies which incorporate the optical elements and the remaining adjustment controls.

Eye Relief (Fore and Aft) Adjustment. Moves the entire binocular assembly toward or away from the eyes.

Tilt Adjustment. Tilts the binocular assembly to align the optical axes of the monocular assemblies with the visual axes of the eyes.

Interpupillary Distance (IPD) Adjustment. Moves the monocular assemblies laterally to match the distance between the eyes. Each monocular adjusts independently.

Objective Focus Ring. Focuses the goggles for distance.

Diopter Focus Ring. Focuses the image on the retina of the eye.

Low Battery Indicator. A small red light emitting diode (LED) provides warning of impending battery failure (Fig. 4).

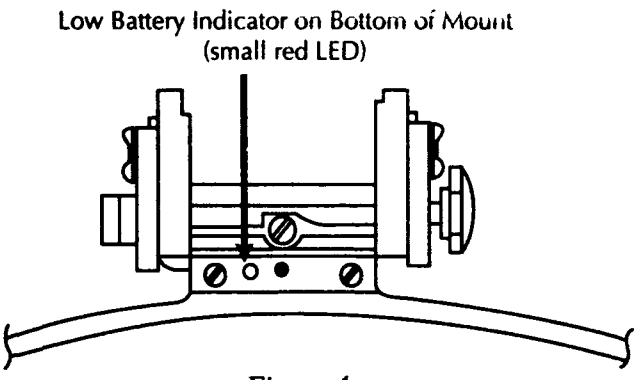


Figure 4
Low Battery Indicator

ADJUSTMENT AND ASSESSMENT PROCEDURES

Adjustment procedures should be performed in a 20-foot eye lane using a USAF NVG resolution chart illuminated by an appropriate source. It is recommended that the 100% contrast chart be used. See the SUPPORT ISSUES section for details on how to acquire a resolution chart and how to construct an eye lane illumination source. The purpose of using the NVG eye lane is two-fold. First, it provides a place to adjust the NVGs. Second, it checks the performance of the device itself. The preflight adjustment/assessment procedures are divided into four parts: (a) inspection and initial adjustment, (b) goggle alignment, (c) focusing, and (d) assessment of function.

Inspection and Initial Adjustment

Perform the following procedures prior to donning the helmet/NVGs.

Inspect Helmet. Perform the usual preflight inspection of the helmet and helmet components.

Inspect Mount Assembly. Ensure that the mount assembly is correctly positioned and firmly attached to the helmet. An improperly positioned mount assembly may make it impossible to achieve proper positioning (alignment) of the goggle.

Load Battery Compartment. Ensure that the switch is in the off position. Insert the batteries with the positive poles pointing outward. If spare batteries are carried, they should be placed in a small resealable plastic bag or protected with some type of nonconductive material.

WARNING

To avoid venting or explosion DO NOT recharge, short circuit, puncture, mutilate, or expose lithium batteries to temperatures higher than 180 degrees F. The terminals should not be exposed to water, corrosive compounds, or conductive materials (loose change or car keys).

If the battery compartment becomes hot to the touch, turn the goggle off immediately. Allow the batteries to cool for at least one hour before removing them.

Inspect Binocular Assembly. Check the overall condition and security of the individual monocular assemblies. Make certain that all adjustments function properly and components move freely and smoothly. Check for loose parts or broken wiring.

Inspect Lenses. Inspect the lenses and clean if any soiling is present. Dust or particulate matter should be removed with a soft brush. Do not wipe the lenses with anything other than lens paper or a lens cleaning cloth specifically manufactured for that purpose.

Set Diopter. Set the diopter on each monocular at zero, or to the correct diopter setting if known.

Adjust Eye Relief (Fore and Aft Adjustment). Position the binocular assembly at its most forward position (away from the eyes). If the correct setting is known, it can be preset. However, it is important that the binocular assembly be adjusted far enough forward so that it does not contact the face, spectacles, or other personal equipment when the goggle is first donned and rotated down to the operating position.

Center Tilt. Set the tilt lever at its centered position.

Set IPD. There are two sets of scales for the interpupillary distance, one over each monocular assembly (Fig. 5). If the scales are correctly placed and numbered from inside out, and if the IPD is known, it can be set in advance and rechecked after the goggles are donned. However, some early production F4949 NVGs have been marked incorrectly and presetting the IPD is not feasible with these goggles.

If the IPD is not known, a millimeter ruler can be used to measure the distance between the center of the pupils while the individual is looking at an object at least a few feet away.

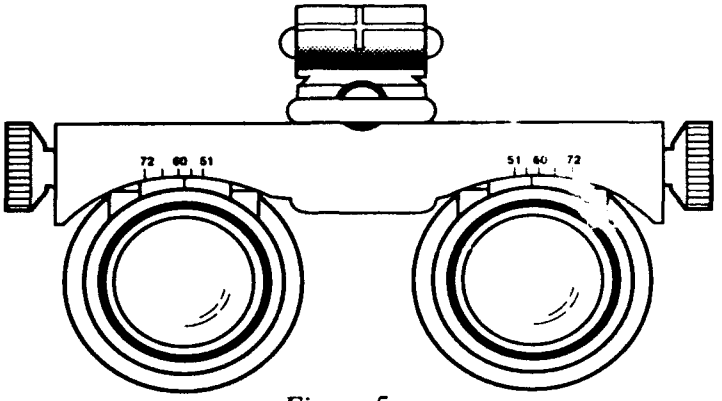


Figure 5
IPD Scales on Each Monocular

Adjust Vertical. Set the binocular assembly to a position centered between the highest and lowest limits.

Don Helmet. Don the helmet. Fasten and adjust the chin strap. If an oxygen mask is worn, it should be attached and adjusted as it would be for flight.

Attach and Remove Binocular Assembly. Align the spring loaded bearings of the binocular assembly with the grooves in the mount (Fig. 6) and push gently until the assembly snaps into place. Do not exert excessive force. If too much force is required, it is an indication that the bearings are not properly aligned and the goggle may fail to seat properly or become jammed in the mount.

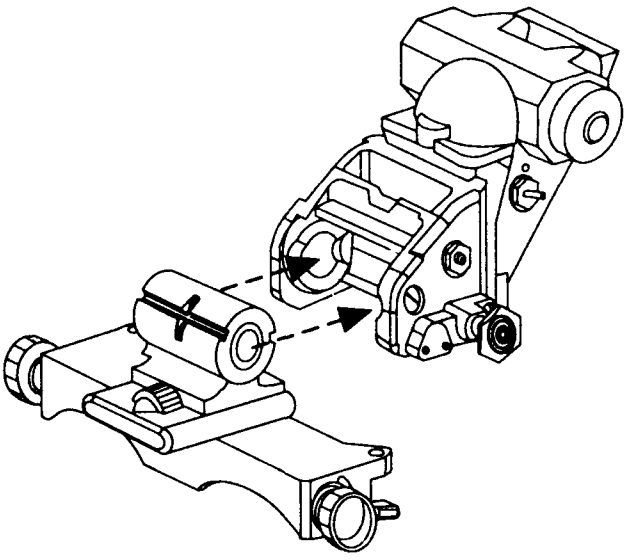


Figure 6
Attaching the Binocular Assembly

CAUTION

Do not release the binocular assembly before confirming that it will lock securely in the stowed position.

The goggle will latch in the stowed position only if it is mounted correctly. Occasionally, the binocular assembly will seem to "snap into place" only to fall to the floor when released, usually sustaining damage. Latching in the stowed position not only confirms that the binocular assembly is properly seated in the mount, it also indicates that the goggle has not been mounted backwards, a surprisingly easy mistake that everyone makes sooner or later.

Remove the binocular assembly by unlatching the goggle and turning the binocular assembly upward to a vertical position. Pull the binocular assembly straight forward out of the mount, preferably using both hands. If only one hand is free, the goggle can be detached by pulling forward on one side.

The binocular assembly should be in a vertical position during removal so that the force exerted to pull it from the mount is approximately perpendicular to its longitudinal axis. This will help prevent damage to the mounts of the individual monocular assemblies, and preclude inadvertent changes in the eye relief (fore and aft adjustment) of the goggle.

Practice mounting and removing the goggle until comfortable with the procedures.

Alignment Procedures

Proper alignment is important because best visual performance is possible ONLY when the optical axis of the device is perfectly aligned with the visual axis of the eye (Fig. 7). For this reason, precise focus is not possible until proper alignment has been accomplished.

Once in the eye lane with helmet and NVGs donned, turn the lights off and turn on the NVGs.

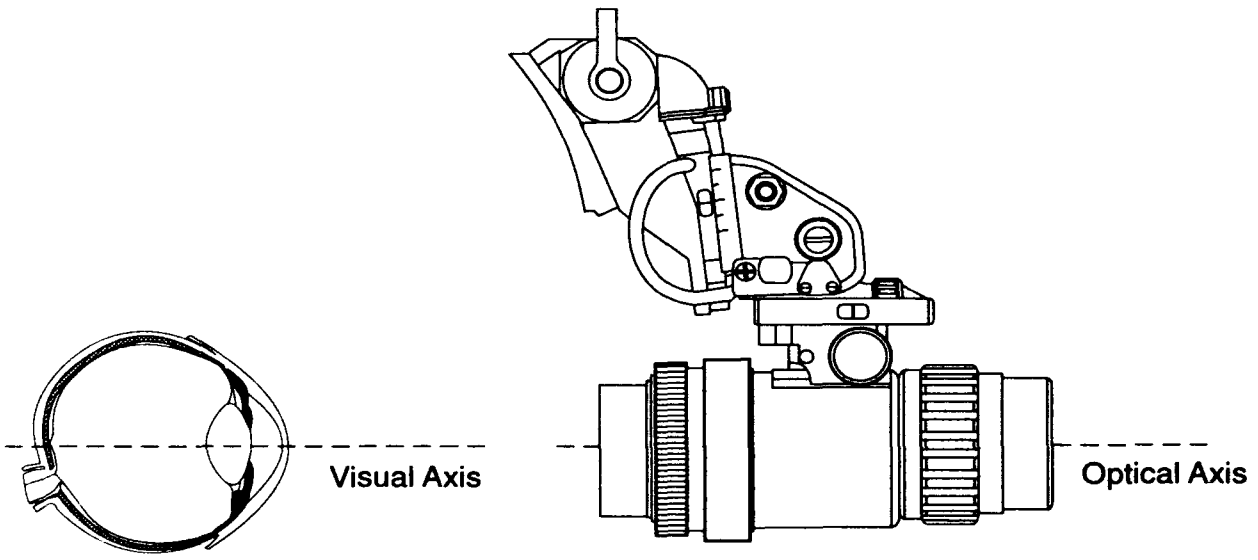


Figure 7
Alignment of Optical Axes

CAUTION

Do not turn on NVGs in a well-lighted area. Repeated exposure to bright light may result in a reduction in the life of the intensification tubes.

Vertical Adjustment. Adjust the vertical position of the binocular assembly using the vertical adjustment knob. The binocular assembly should be located directly in front of the eyes.

Tilt Alignment. Adjust the tilt so that the optical axis of the binocular assembly is perfectly aligned with the visual axis of the eye. Changes in vertical position usually require an adjustment of tilt, and vice versa.

Eye Relief (Fore and Aft) Adjustment. Move the binocular assembly aft toward the face using the fore and aft adjustment knob. Ideally, the NVG should be located as close to the face as possible without impairing vision inside the cockpit (around the goggle). However, the goggle should **never** be close enough to the face that it contacts spectacles or eyelashes.

IPD Adjustment. Confirm that the IPD is correct. If properly set, the two images should overlap to form a single sharp image which may or may not be perfectly round. It may be helpful to evaluate each side individually. Perfect alignment of each tube is indicated when the image appears directly in the center of the eyepiece lens with no shading or clipping of the edge.

Evaluate Image. When the goggles are correctly aligned, there should be no shading or clipping of any part of the image. If shading is present, attempt to eliminate it by making adjustments in the direction of the shading. If there is insufficient travel in the goggle adjustments, move the entire helmet in the direction of the shading. If proper alignment can only be accomplished by moving the helmet, it is an indication that the mount assembly is not properly positioned on the helmet. Notify life support personnel so that the problem can be corrected.

Focusing Procedures

Move to a point 20 feet from the resolution chart. It is important to view the chart from the proper distance because a difference of only a few inches can affect the apparent function of NVGs. Start by using the coarser grids, not trying to focus on the fine grids until after the diopter adjustment has been made.

The objective is to be able to see the grids well enough to determine whether or not the lines are horizontal or vertical. The grids may not be perfectly clear, but the direction of the lines should be readily apparent.

Objective Focus. With one eye closed or one tube covered, turn the objective lens (outer ring) of the opposite tube while looking at one of the coarser grids. Attempt to bring the lines into sharp focus.

Diopter Focus. Next, turn the diopter focus adjustment (inner ring) counterclockwise until the image is blurred. Pause for one to two seconds, then turn the diopter adjustment clockwise until the image just becomes quite sharp – then stop.

CAUTION

Do not turn the diopter adjustment beyond the point at which the image becomes sharply focused, even though the image remains clear.

Performed correctly, this procedure focuses the image on the retina of the eye without accommodative effort by the eye muscles. Rotating the diopter ring beyond this point forces the eye muscles to actively work to keep the image focused. Over time the eye muscles will become fatigued and unable to maintain focus. This results in a gradual loss of visual acuity and depth perception, and often causes severe eyestrain headache.

If in an attempt to find the point of sharp focus the diopter ring is rotated too far, the procedure should be repeated beginning with the initial counterclockwise rotation.

Readjustment of Objective Focus. Once the diopter adjustment has been made, visual acuity should be evaluated. If all nine of the grids can be seen well enough to definitely determine the direction of the lines, the monocular has been focused correctly and is functioning adequately. If fewer than nine grids can be seen, an attempt should be made to refocus the objective (front) ring until the orientation of all nine is visible.

Focus of the Opposite Monocular. After focus of the first monocular has been accomplished, the same procedures are employed to focus and evaluate the remaining monocular. Do not be concerned if one side is slightly better than the other. Slight differences in the performance of individual intensification tubes are common.

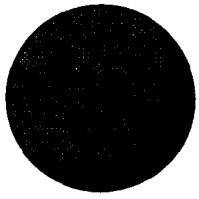
Assessment of Function

Evaluate Visual Acuity. Use Table 1 to determine visual acuity with the USAF NVG Resolution Chart. Visual acuity obtained with both eyes should always be at least as good as the vision of the best side. If this is not the case, the goggles should be returned and another pair obtained. Further, it is recommended that the minimum acceptable visual acuity be 20/40.

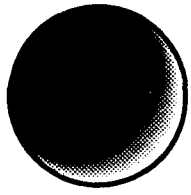
Table 1. Visual Acuity as Determined with the USAF NVG Resolution Chart

# of Grids Seen	Visual Acuity
9	20/35
8	20/40
7	20/45
6	20/50
5	20/60
4	20/70
3	20/80
2	20/90
1	20/100

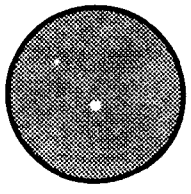
Evaluate Image. A number of image peculiarities and defects exist. The most common types are the following:



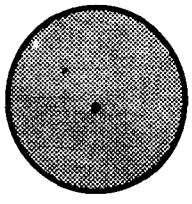
Shading. Appears as a shaded or indistinct area along the edge of the image. Attempt to eliminate it by moving the goggle toward the shading. If this is unsuccessful, do not use the goggle.



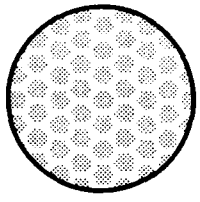
Edge Glow. Appearing as a bright area along the outer edge of the image, edge glow is most often the result of a bright light source. If noted, turn away from any bright lights or hold one hand over the objective lens. If the edge glow persists, it is an indication of damage to the intensification tube and the goggle should not be used.



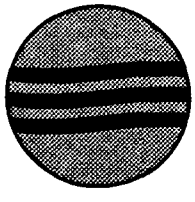
Bright Spots. Constant or flickering bright spots may appear anywhere in the image. Hold one hand in front of the objective lens. If bright spots are still present and they degrade the image and/or are distracting, do not use the NVG.



Dark Spots. Dark or black spots in the image. If large, numerous or located near the center of the image, the goggle should not be used. Maintenance should be notified so that the NVG can be checked to see whether or not it meets the military specifications.



Honeycomb. A honeycomb-like pattern in the image which is most often seen in high light-level conditions. If it is obvious or distracting in the eye lane, the NVG should not be used.



Distortion. Optical bending of a viewed object. Move the NVGs back and forth and up and down rapidly in the eye lane keeping the chart in the field of view. If distortion is present and it is deemed likely to interfere with normal operations, do not use the NVG.

Flicker. The NVG image from one or both tubes may flash or flicker. The effect may occur only at a particular illumination level. If flicker is noted, do not use the NVG.

Scintillation. A normal finding at low light levels. It is seen as a sparkling effect over the image and represents electronic noise created at the high gain levels caused by low illumination conditions. In flight, it can be an indication of decreasing illumination caused by such things as worsening weather conditions or flight into shadows.

Note Adjustment Settings. Remove the goggle from the mount and note the diopter and IPD settings. It is important to confirm that these settings are correct before donning the NVG in the aircraft.

CAUTION

Turn NVGs off prior to turning on eye lane lights and/or leaving the eye lane.

Cockpit Procedures

Before donning NVGs in the aircraft, confirm that the IPD and diopter settings are the same as determined in the eye lane.

Because the device was focused at 20 feet in the eye lane, it will be necessary to refocus at infinity before flight. This can be accomplished by focusing on an object at least 75-feet distant, preferably one with well-developed vertical or horizontal features. It must be illuminated well enough to be easily seen with NVGs, but not so brightly lit that the image blooms or washes out. Avoid focusing on incompatible lights because the halo effect they create makes it difficult to discern when the image is in precise focus. If the aircraft is equipped with a head-up display (HUD), the HUD symbology can be used since it is collimated to infinity. If there is nothing else available, a bright star or distant light can be used as a last resort.

Remember, refocus using the objective (front) ring **ONLY**. The diopter adjustment should never need to be changed from the setting determined in the eye lane.

Practice donning and emergency removal of the goggles in the aircraft several times before flight.

As the helmet settles or rotates during flight, it may be necessary to make minor adjustments to the elevation and tilt, and possibly the eye relief. However, once adjusted correctly, the IPD and diopter should **never** need to be reset in flight.

CAUTION

Do not change IPD or diopter settings during flight.

SUPPORT ISSUES

Resolution Chart. The 100% resolution chart (Fig. 8) designed by the Armstrong Laboratory's Visual Display Systems Branch at Wright-Patterson AFB, OH, is recommended for use. It can be acquired from VisTech Consultants in Dayton, OH (phone 513-454-1399).

Eye Lane and Illumination Source. It is imperative that eye lane and illumination source instructions be followed accurately. This will ensure proper NVG focusing and evaluation. For proper instructions, contact the USAF Night Vision Program Office of the Aircrew Training Research Division, Armstrong Laboratory in Mesa, AZ (DSN 474-6561, COMM 602-988-6561).

Preflight and Adjustment Quick References. An abbreviated set of preflight and adjustment instructions are attached at the end of this document (Appendices A and B). Place them in an area easy to see and use, in or near the NVG eye lane.

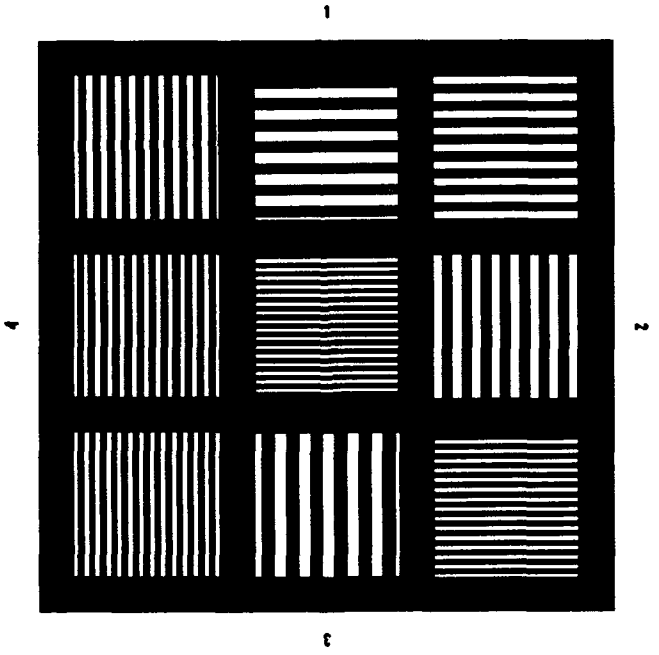


Figure 8
USAF NVG Resolution Chart

Appendix A

F4949 INSPECTION AND INITIAL ADJUSTMENT PROCEDURES

1. INSPECT HELMET
2. INSPECT MOUNT ASSEMBLY - Check overall condition and adjustment knobs for free movement.
3. LOAD BATTERIES
4. INSPECT BINOCULAR ASSEMBLY - Check overall condition and adjustment knobs for free movement. Clean lenses with lens paper only.
5. SET DIOPTER TO ZERO OR KNOWN SETTING
6. SET EYE RELIEF FULL FORWARD AWAY FROM EYES
7. CENTER TILT
8. SET IPD
9. SET VERTICAL AT CENTERED POSITION
10. DON HELMET AND ATTACH NVGs
11. PRACTICE MOUNTING AND REMOVING THE NVGs

Appendix B

F4949 ADJUSTMENT AND ASSESSMENT PROCEDURES

1. ROOM LIGHTS - Off
2. GOGGLE POWER - On
3. ALIGNMENT PROCEDURES
   - Adjust vertical
   - Adjust tilt
   - Adjust eye relief
   - Assess IPD
   - Evaluate image
4. FOCUSING PROCEDURES - One eye at a time (close other eye or cover lens)
   - Focus objective (outer) ring
   - Focus diopter (inner) ring
     - counterclockwise until blurred
     - clockwise until just sharpened
     - readjust objective focus if necessary
5. ASSESSMENT OF FUNCTION - Evaluate visual acuity with both eyes open

Visual Acuity as Determined with the USAF NVG Resolution Chart

# Correct	Visual Acuity	# Correct	Visual Acuity
9 of 9	20/35 or better	4 of 9	20/70
8 of 9	20/40	3 of 9	20/80
7 of 9	20/45	2 of 9	20/90
6 of 9	20/50	1 of 9	20/100
5 of 9	20/60	0 of 9	????

Note IPD and diopter settings

6. COCKPIT PROCEDURES
   - Confirm IPD and diopter settings
   - Refocus to infinity
   - Practice emergency removal